Experiments in Etching

Edgar Refskegg

January 15, 2020

Contents

Overview

The way copper is usually etched is done using products easily obtained for home use. We usually follow standard PCB etching procedures using press-n-peel paper, an iron or heat press, and ferric chloride (FeCl3). Ferric Chloride is not easy to dispose of properly, and it requires careful handling procedure. Over the weekend of April 19, 2019, we (Brose and I) experimented a bit with a couple different etching styles and compared their results.

The two etchants we attempted were:

- Ammonium Persulfate
  - This is sold as a PCB etchant, and unfortunately there isn't a whole lot of information about it. This was diluted according to package instructions.
- Salt water etch
  - This involves a 1:5 salt water bath with a steel wire, copper, and current.

  Note: We used brass (and bronze I think) and nickel silver for etching with these methods, so we're unsure of the effectiveness on pure copper.

Overall the experimentation was short of successful. However, we indeed learned a lot. It's absolutely possible that these etchants would be much more successful with pure copper. I'd like to try the salt water etch again using only copper. We also learned that basically using ferric chloride provides the most consistent and quality results, so in the future we will seek to improve our methods using it.

Ammonium Persulfate

The bottle we obtained is sold by MG Chemicals, who is a common supplier of other chemicals we use, mainly ferric chloride. It is sold as a PCB etchant. One of the few references I could find about this indicates that this etchant is expensive and difficult to use, which is what we found.[1] The instructions on the bottle say to mix the solid powder with about a gallon of water, which we did.

When we added our metal to the etchant after it was diluted per instruction we saw virtually no etch. After some time we decided to heat the solution over a wood stove. After a sufficient temperature was reached, the metal began to etch. Slowly. After several hours we obtained an etch deep enough to be useful, and disposed of the rest of the solution. We weren't impressed.

It seems that this etchant is good for really thin etches. We require fairly deep etching as far as these things go (not microns thick like a circuit board), so this chemical ultimately was no good for our purposes.

Salt Water Etch

A basic tutorial was found on instructables.[2] We followed the tutorial pretty closely and didn't have any success. Perhaps this was because we used two batteries instead of three, but in any case we had very little success. The reaction blew the electrical tape off of the copper and ultimately simply didn't etch. We checked the polarity of the batteries and observed that it was correct.

Thinking that low power might be the issue, we used a 9 V 100 mA AC/DC power supply next. The first combination of wires did not work. However, after swapping the leads we were able to get a nice clean etch on the metal we used. The etch was done on a piece of 18 ga brass (or bronze, can't remember) so it might have been even better on pure copper.

[1] Open Circuits, "Chemical Etchants" (Open Circuits, n.d.), http://www.opencircuits.com/Chemical_Etchants.
[2] Marcellahella, "Salt and Water Etching," n.d., https://www.instructables.com/id/SALT-AND-WATER-ETCHING/.

Others

We didn't experiment with anything else, but there are other ways to do the same thing. A lot of people who etch using electricity use a copper nitrate electrolytic solution.[3] This has the key benefit of being self-replenishing. However, it is more of a hassle to dispose of than Ferric Chloride.

Additionally, there is what is called the Edinburgh etch. This method uses FeCl3 as we do, but with the addition of citric acid. The idea is that the citric acid dissolves and of the precipitate that becomes stuck to the copper (this action prevents even etching). With those salts dissolved, the etch becomes faster and more consistent. We have citric acid on hand and will experiment with that next.

Conclusion

Ultimately these two methods ended up being less than optimal. The Ammonium Persulfate didn't perform very well as a whole, and the salt water etch, while effective, requires a lot of maintenance and set up. It is likely that each of these factors could be mitigated by further experimentation and practice, however.

My intepretation of the results is essentially this: do whatever feels most comfortable. We have the most experience with ferric chloride so for us it is the easiest and most reliable method. Since we began using it we know many of the nuances and don't have to experiment as much. In order to get up to speed with the other etchant methods we would have to experiment and basically start over our process. As a result, we seek to focus our efforts on improving our resist application techniques and possibly determining ways to speed up a FeCl3 etch.

[3] Dory Ben, *Electrolytic Etching Copper and Silver Using Copper Nitrate, a Replacement for Table Salt (Nacl)*, n.d., https://carolholaday.files.wordpress.com/2013/02/copper-nitrate-electro-etching-instruction.pdf.

Bibliography

Ben, Dory. *Electrolytic Etching Copper and Silver Using Copper Nitrate, a Replacement for Table Salt (Nacl)*, n.d. https://carolholaday.files.wordpress.com/2013/02/copper-nitrate-electro-etching-instruction.pdf.

Circuits, Open. "Chemical Etchants." Open Circuits, n.d. http://www.opencircuits.com/Chemical_Etchants.

E., Jemmott Deborah. "Galvanic Etching Checklist," n.d. https://www.ganoksin.com/ftp/Galvanic-Etching.pdf.

Hawthorne, J. G., and C. S. Smith. *On Divers Arts: The Foremost Medieval Treatise on Painting, Glassmaking, and Metalwork*. Dover Art Instruction. Dover Publications, 1979. https://books.google.com/books?id=MMiLTJqvYnYC.

marcellahella. "Salt and Water Etching," n.d. https://www.instructables.com/id/SALT-AND-WATER-ETCHING/.

O'Neill, J. P., Musée du Louvre, and N. Y. Metropolitan Museum of Art New York. *Enamels of Limoges: 1100-1350*. Metropolitan Museum of Art, 1996. https://books.google.com/books?id=i4okAQAAMAAJ.

Wardropper, I., and J. B. Day. *Limoges Enamels at the Frick Collection*. Frick Collection, 2015. https://books.google.com/books?id=3LcNrgEACAAJ.